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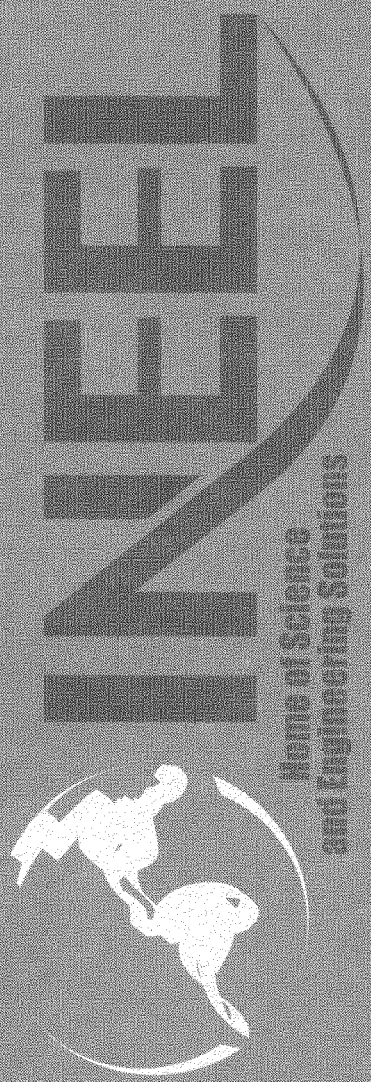
Environmental and Operational Year-End Data Report for the OU 7-08 Organic Contamination in the Vadose Zone Project - 2002

L. Todd Housley
March 2003



Idaho National Engineering and Environmental Laboratory
Bechtel BWXT Idaho, LLC

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Approved

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ABSTRACT

Since January 1996, Operable Unit 7-08 has been using soil vapor extraction to remove organic contamination from the vadose zone outside the disposal pits and trenches in the Subsurface Disposal Area within the Radioactive Waste Management Complex at the Idaho National Engineering and Environmental Laboratory. The vadose zone contains volatile organic compounds, primarily in the form of organic vapors that have migrated from buried waste in the pits and trenches.

This report documents operational and sample data for Operable Unit 7-08 recorded between July 1 and December 31, 2002. During that time, approximately 6,784 kg (14,958 lb) of total volatile organic compounds were removed from the vadose zone and oxidized through thermal or catalytic processes. Vapor Vacuum Extraction with Treatment Units A, B, and D removed approximately 3,020 kg (6,657 lb), 2,769 kg (6,106 lb), and 996 kg (2,195 lb), respectively.

Carbon tetrachloride is the largest contributor to the volatile organic compound mass removal, representing 57% of the total for this operating cycle. Isoconcentration plots of current carbon tetrachloride vapor data, at a depth of approximately 21 m (70 ft), indicate an overall decrease in the areal extent of the plume when compared to data taken before operations at the same depth. Data also suggest a decrease in carbon tetrachloride concentration at the center of the plume.

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FIGURES

TABLE

ACRONYMS

B&K	Brüel and Kjær
bgs	below ground surface
DQO	data quality objective
FCV	flow control valve
INEEL	Idaho National Engineering and Environmental Laboratory
OCVZ	organic contamination in the vadose zone
OU	operable unit
PLC	programmable logic controller
RPD	relative percent difference
RWMC	Radioactive Waste Management Complex
SDA	Subsurface Disposal Area
TPR	technical procedure
VOC	volatile organic compound
VVET	vapor vacuum extraction with treatment

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1. INTRODUCTION

1.1 Purpose

This report documents the operational activities of Operable Unit (OU) 7-08 through the end-year reporting period of operations for calendar year 2002 (i.e., July 1 through December 31, 2002). Operable Unit 7-08 is defined as the organic contamination in the vadose zone (OCVZ) at the Subsurface Disposal Area (SDA) of the Radioactive Waste Management Complex (RWMC) at the Idaho National Engineering and Environmental Laboratory (INEEL).

Operable Unit 7-08 extends from the land surface to the top of the Snake River Plain Aquifer approximately 177 m (580 ft) beneath the RWMC. Disposal pits and trenches within the SDA are not part of OU 7-08. The vadose zone contains volatile organic compounds (VOCs) primarily in the form of organic vapors that have migrated from the buried waste in the SDA. Figures 1 and 2 are maps showing the locations of the INEEL and the SDA, respectively.

Operable Unit 7-08 is the designation recognized under the Federal Facility Agreement and Consent Order (DOE-ID 1991) and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) (42 USC § 9601 et seq.) for OCVZ remediation beneath the RWMC, which comprises the SDA. In accordance with the *OU 7-08 Record of Decision* (DOE-ID 1994), the selected remedy for OCVZ consists of the extraction and destruction of organic contaminant vapors present in the vadose zone and the monitoring of vadose zone vapors in the Snake River Plain Aquifer beneath and within the immediate vicinity of the RWMC.

1.2 Background

To implement the selected remedy described in the *OU 7-08 Record of Decision*, three vapor vacuum extraction with treatment (VVET) units with recuperative flameless thermal oxidation systems were installed within the boundaries of the SDA and began operating in January 1996. Two of the flameless thermal oxidation system units (designated as Units A and B) were designed to extract and treat vapors from two extraction wells each, and one flameless thermal oxidation system unit (designated as Unit C) was designed to extract and treat vapors from one extraction well. During the spring of 2001, Unit C was decommissioned and removed from the SDA. Unit D, an electrically heated catalytic oxidizer, was installed at the previous Unit C location. Currently, Unit A treats vapors from Extraction Well 8901D, Unit B treats vapors from Extraction Well 2E, and Unit D treats vapors from Extraction Well 7V.

In 1994, 15 new vapor extraction and monitoring wells were installed in, or adjacent to, the SDA. In addition, one extraction well, Well 8901D, and five monitoring wells, Wells D02, 8801, 8902, 9301, and 9302, were incorporated for extracting and monitoring VOC vapors. In 2000, Wells DE-1 and M17S were installed to provide additional monitoring. In 2001, Wells 6E and 7E were installed to provide extraction capability near source areas above 24 m (80 ft) below ground surface (bgs). Further OCVZ well drilling began during the end-year 2002 (see Section 2.7.5) operational period to provide additional extraction and monitoring locations.

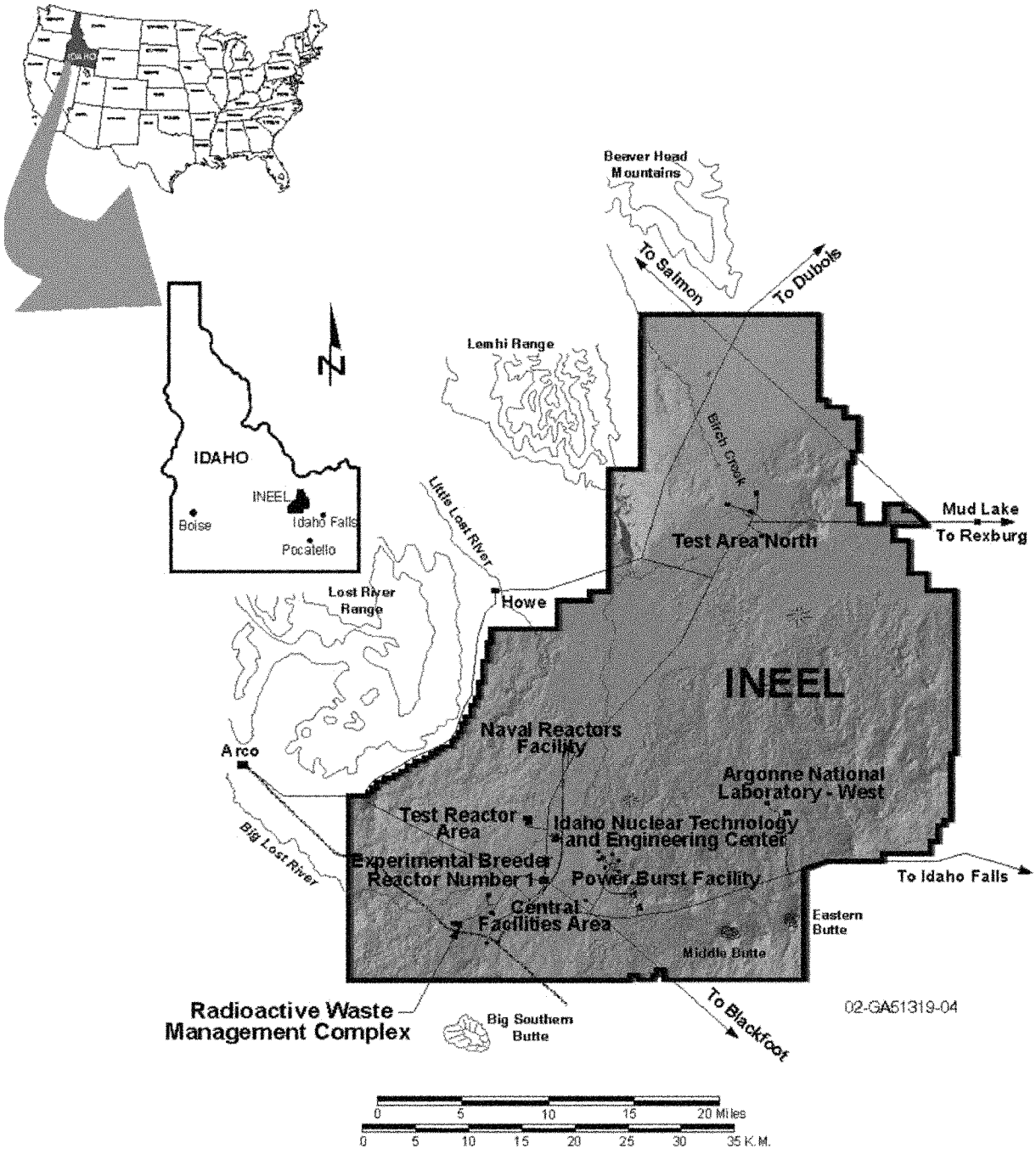

Figure 1. Map of the Idaho National Engineering and Environmental Laboratory showing the location of the Radioactive Waste Management Complex.

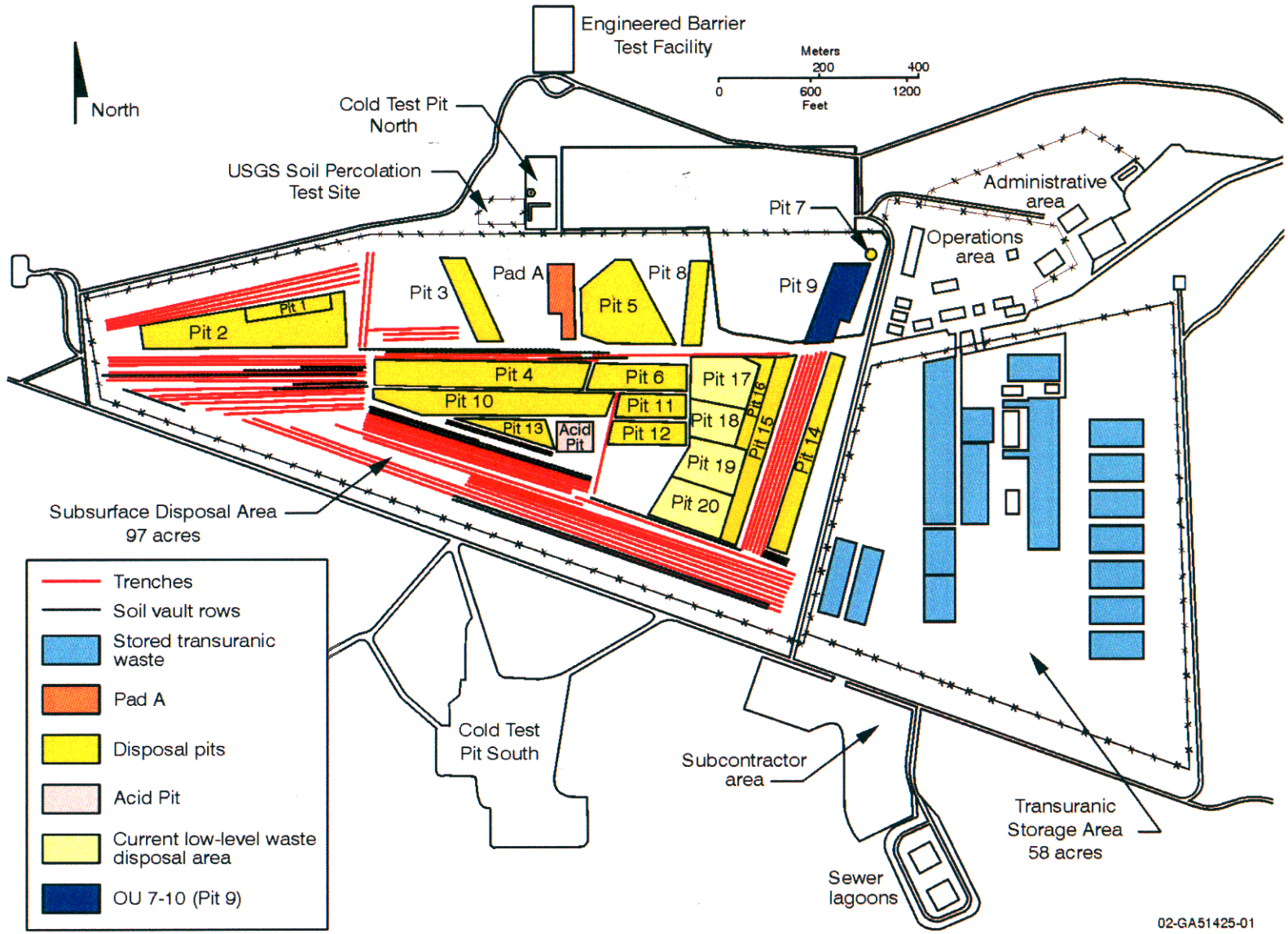

Figure 2. Map of the Radioactive Waste Management Complex showing the location of the Subsurface Disposal Area.

2. DISCUSSION OF ENVIRONMENTAL AND OPERATIONAL SAMPLE DATA

To calculate VOC mass removal rates and to monitor effectiveness of the VVET system, vapor samples are collected at the inlet of the VVET units and analyzed using a Brüel and Kjær (B&K) photoacoustic multi-gas analyzer. This section presents a discussion of the following data quality and monitoring objectives for the project:

- Precision
- Accuracy
- Completeness
- Comparability
- Mass removal
- Spatial and temporal distribution of VOCs in the vadose zone
- System optimization and maintenance.

2.1 Precision

Precision pertains to the sharpness, definition, or focus of a particular data set. Precision implies an exact measurement with little sample-to-sample variation and high repeatability. Two types of sample replicates were analyzed to ensure the quality of collected data. The two classifications of replicates were field splits (repeat) and field duplicates. A field split is a repeat analysis of a field-collected sample used to test the precision of the analytical instrument. A field duplicate is a separate sample collected from the same location at the same time as the original sample. This duplicate sample is used to test the precision of the field collection techniques. Precision was determined by calculating the relative percent difference (RPD) for both the field duplicates and the field splits. A goal was set for precision of less than 30% RPD for all replicate samples (INEEL 2002). The RPD is calculated as shown in Equation (1) where C_1 and C_2 are the respective analyte concentrations in a replicate sample pair.

$$RPD = 100 \times \frac{\left(|C_1 - C_2|\right)}{\left(\frac{C_1 + C_2}{2}\right)}. \quad (1)$$

Samples were analyzed, as in previous operating cycles, using a B&K gas analyzer. Sample precision of duplicate or repeat samples of chloroform ($CHCl_3$), 1,1,1-trichloroethane, tetrachloroethylene, trichloroethylene, carbon tetrachloride (CCl_4), and total VOCs was recorded (see Appendix A). A total of 104 sample replicates (duplicate and split sample pairs) were collected during the operating cycle, resulting in a total of 520 possible component pairs. Seventy-five of the 104 sample-replicate pairs exhibited RPDs of less than 30% (INEEL 2002) for all analyzed components. Of the 29 sample pairs that exceeded 30% RPD, 11 were the result of measured analyte concentrations (for one or more components) below the 1-ppmv B&K detection limit. The measurement precision decreases as sample concentrations approach the 1-ppmv detection limit of the B&K, resulting in the observed increase in RPD. For any samples resulting in a negative value, the concentration was assumed to be zero.

2.2 Accuracy

Standards (i.e., premixed gas samples at verified concentrations) were purchased at concentrations of 1, 100, 500 and 1,000 ppm. Constituent concentrations of each of the standard gasses are detailed in Table 1. These standard gasses were analyzed before each set of vapor samples were analyzed to quantify and validate instrument performance. The accuracy of the B&K is illustrated in Appendix B.

Table 1. Standard gas compositions.

Constituent	1 ppmv Standard	100 ppmv Standard	500 ppmv Standard	1,000 ppmv Standard
Chloroform	1.01 ppmv	100.4 ppmv	498.60 ppmv	—
1,1,1-trichloroethane	0.99 ppmv	99.8 ppmv	497.46 ppmv	—
Tetrachloroethene	1.02 ppmv	99.9 ppmv	498.25 ppmv	—
Trichloroethene	1.01 ppmv	100.1 ppmv	498.57 ppmv	—
Carbon tetrachloride	1.01 ppmv	100.5 ppmv	498.87 ppmv	998.7 ppmv

Accuracy pertains to the extent to which instrument readings approach the true values and are free from error. Instrument accuracy was tested using the various sample standards before analyzing each sample set during the end-year 2002 operating period. Analytical results for the 1.01-ppmv CCl_4 standard sample were measured with reported concentrations ranging from 78 to 3,228% (see Section 2.2.1) of the known concentration. Analytical results for 36% of the 1.01-ppmv CCl_4 standard samples exceed the prescribed acceptable ±20% error bound limit. Analytical results for the 100.5-ppmv CCl_4 standard samples are much less scattered than those of the 1.01-ppmv CCl_4 standard, with results that range from 83 to 155% of the known concentration. Analytical results for only 8% of the 100.5-ppmv CCl_4 standard samples exceed the prescribed acceptable ±20% error bound limit. Analytical results for the 498.87-ppmv CCl_4 standard sample were measured with reported concentrations ranging from 68 to 98% of the known concentration. Analytical results for 15% of the 498.89-ppmv CCl_4 standard samples exceed the prescribed acceptable ±20% error bound limit. Analytical results for 3% of 998.8-ppmv CCl_4 standard samples exceed the acceptable ±20% error bound limit with results that range from 79 to 102% of the known CCl_4 concentration. Analytical results have fallen within the acceptable ±20% error bound limit of known CCl_4 concentrations 83% of the time for all standard samples. The accuracy of the B&K is illustrated in Appendix B.

2.2.1 Analytical Performance Enhancement

The project has made an attempt to improve the quality of data collected and the confidence with which these data can be used. Improvement has been made in sample handling and storage procedures, and calibration and performance optimization of existing analytical equipment by closer adherence to sampling and analysis procedures. As a result, generally increased quality has been achieved in analytical performance.

However, during the end-year 2002 operation period, the accuracy of the B&K was quantified, and the results showed a significant decrease in accuracy with the 1.01-ppmv and, to a lesser extent, the 100.5-ppmv CCl_4 standard gases. These results are shown in Appendix B. Beginning in October 2002, increased levels of error began to occur. From the beginning of the reporting period through October 17, 2002, 30 of the 1.01-ppmv standard gas samples were analyzed. Only two were outside the ±20% error bound limit. After October 17, 2002, 17 of the 1.01-ppmv standard gas samples were analyzed. Of these 17, only two were within the ±20% error bound limit.

The apparent reduction in analytical accuracy is actually caused by exchanging pressure regulator valves between standard gas cylinders rather than analyzer error. Standard gases are stored in high-pressure gas bottles fitted with pressure regulator valves. In October 2002, the regulator valves from the 1- and 100-ppmv standard gas bottles were removed and used on standard gas bottles from another project containing much higher concentrations of VOCs. The regulator valves from the 500- and 1,000-ppmv standard bottles were then exchanged between the 1- and 100-ppmv standard bottles. Internal diaphragms contained within the regulator valves were saturated with VOCs from the higher concentration standards and thereby contaminated the 1- and 100-ppmv standard samples. As a result, residual VOCs were introduced into the lesser concentrated standard samples causing the results to exceed the ±20% error bound limit. The practice of exchanging regulators between bottles has been identified as the contributing factor of the sample contamination. New regulators have been purchased and in the future regulators will not be exchanged between bottles.

2.3 Completeness

A total of 788 samples were targeted during the end-year 2002 period of operation. This total included 684 well samples, 69 repeats, and 35 duplicates. Ultimately, 714 (91% of target) samples were actually analyzed and recorded. This included 610 well samples, 65 repeats, and 39 duplicates. Repeats and duplicates were targeted for analysis rates of at least 1:10 and 1:20, respectively. Factors affecting well completeness include sample bag failure and inaccessibility to well locations. For example, during the months of August through November, Well D02, which contains three vapor ports and is sampled on a monthly basis, was not sampled because of the presence of mice droppings and the potential for Hanta Virus exposure.

Percent completeness of the sampling and analytical data was calculated for this operating cycle using Equation (2). Completeness of sampling is detailed in Table 2 for monthly monitoring, and duplicate and repeat samples. Because samples are considered noncritical during VVET operations, a target for completeness of 90% is designated by the *Data Quality Objectives Summary Report for Operable Unit 7-08 Post-Record of Decision Sampling* (INEEL 2002).

$$\%Complete = 100 \times \frac{(\text{Number of samples analyzed})}{(\text{Number of samples targeted})} . \quad (2)$$

Table 2. Completeness of sampling.

Type	Samples Targeted	Samples Analyzed	Percent Complete
Monthly monitoring samples	684	610	89%
Monthly duplicates	35	39	111%
Monthly splits (repeats)	69	65	94%
Total samples	788	714	91%

2.4 Comparability

The data set included in this report (i.e., July 1, 2002, through December 31, 2002) is comparable to that of previous data sets because the same field collection technique, field procedures, sample-handling methods, and quality assurance and quality control procedures were applied. Analytical detection limits are similar because the same field instrumentation was used (i.e., B&K gas analyzer). Duplicate field samples were targeted for collection at a rate of roughly 5% while field splits (repeats) were targeted at a rate of 10%, in accordance with the *OCVZ Data Quality Objectives* (DQO) report (INEEL 2002).

On a monthly basis, samples were collected from 105 vapor ports within and in the immediate vicinity of the SDA boundary to monitor concentration trends in the VOC plume. On a quarterly basis, 27 additional ports outside the SDA boundary were sampled to monitor the vapor concentrations at various locations ranging up to 2,774 m (9,100 ft) from the VOC source area. Vapor port sampling and analysis was completed in accordance with the OCVZ DQO report.

The statistical analyses for precision and accuracy of four monthly vapor port sampling events (July, August, October, and November 2002) and two quarterly sampling events (September and December 2002) are included in Appendixes A and B.

2.5 Mass Removal

The VOC concentrations of process samples taken from ports on the inlet lines (downstream of the ambient air intake valves) to the VVET units were used to calculate mass removal rates. Samples were taken daily during the normal operations work week (i.e., Monday through Thursday) and the results averaged between sampling events. The results show that approximately 6,785 kg (14,958 lb) of total VOCs were removed during this operating cycle. Units A, B, and D removed approximately 3,020, 2,770, and 996 kg (6,657, 6,106, and 2,195 lb), respectively. The actual operating hours and average daily unit operation parameters (i.e., flow rate, pressure, and temperature) were used for the mass removal calculations (EDF-2157).

Consistent with the analysis of well vapor samples, VVET process samples were analyzed using the B&K analyzer. Section 2.2 presents a discussion of the analyzer accuracy.

Analyte mass-removal estimates for July through December 2002 for Units A, B, and D are presented in Appendix C, Tables C-1, C-2, and C-3, respectively. Shown graphically in Figures C-1, C-2, and C-3 are process sample (i.e., inlet) CCl_4 concentrations for Units A, B, and D, respectively. For comparison, Figures C-4 and C-5 graphically present the mass removal estimates for each analyte during this reporting cycle and since January 1996, respectively. Analyte mass removal estimates for each operating cycle since January 1996 are provided in Table C-4. As shown in this table, CCl_4 is the largest contributor to the mass removal of VOCs with 57% of the total occurring from July through December 2002 and 63% of the total occurring since January 1996.

2.6 Spatial and Temporal Distribution of Carbon Tetrachloride in the Vadose Zone

Spatial and temporal distribution of the CCl_4 concentration in the subsurface is graphically presented in Appendix D. The figures in Appendix D represent a horizontal cross-section of the distribution of the CCl_4 concentration in the SDA at approximately 21 m (70 ft) bgs. Concentration values from four different sampling events were used to prepare the plots (1) before starting the remedial action in January 1996, (2) January 1998, (3) January 2000, and (4) in December 2002. The CCl_4 concentration distribution was kriged[a] by using the Environmental Visualization System software program. Plots of current CCl_4 vapor data, at approximately 21 m (70 ft) deep, indicate an overall decrease in the areal extent of the plume when compared to data taken before operations at the same depth. The vapor data also indicate a decrease in the CCl_4 concentration at the center of the plume.

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a. Kriging is a method of linear regression that takes into account the spatial relationship of a series of points. In this case, concentrations are estimated between actual measured data points, providing insight into what the actual concentration profile might look like at any horizontal level in the contamination zone.

2.7 System Optimization and Maintenance

This section documents treatment system corrective maintenance modifications, preventive maintenance, configuration management, and component calibration activities completed from July through December 2002. Preventive maintenance activities were completed in accordance with the OCVZ VVET preventive maintenance schedule (McMurtrey and Harvego, 2001).

2.7.1 Corrective Maintenance

Corrective maintenance activities are required in response to system failures or breakdowns. Work is performed in accordance with the INEEL "Integrated Work Control Process" (STD-101). During the end-year 2002 reporting cycle, corrective maintenance activities were performed during both planned or uncontrollable downtimes and unplanned downtimes. Activities ranged from software upgrades to mechanical and electrical repairs and are summarized below.

In June 2002, Unit B was shut down temporarily when surveillance identified a problem with the propane vaporizer. The vaporizer was removed, serviced, and reinstalled in early July.

Following an electrical power outage in July 2002, it was discovered that fuses in the sectionalizer had blown. Initially, the outage was attributed to the weather, but was eventually determined to be because of a rodent intrusion that shorted the terminations within the sectionalizer. Repair work on the electrical system, including rebuilding of the power pole and replacement and repair of the fuses and connections in the sectionalizer was completed.

In August 2002, Unit A was shut down to allow placement of a lock out/tag out required for work associated with removal of the pipeline leading to abandoned well 4E so the line would not interfere with well drilling.

During a planned preventive maintenance shutdown in October 2002, field personnel took the opportunity to perform corrective maintenance. Pressure relief and drain valves on the air compressor were replaced.

In early November 2002, Units A and D were shut down temporarily to check tension on newly installed belts and to load revised programmable logic control (PLC) software. Later that month, Unit D was briefly shut down to replace a broken belt on the blower.

In late December 2002, problems again were identified with the propane system on Unit B. Propane lines, check valves, and the sparger were cleaned.

2.7.1.1 Software Upgrades—Software upgrades were made to improve several features of unit operation. Below are the eight items included in the software improvements.

2.7.1.1.1 Pilot Light Ignition Retry with Reduced Purge (EDF-2594). The ladder logic written for VVET units A and B previously provided a 5-minute preheat purge and then energized the ignition transformer for 10 seconds. If the pilot light did not ignite (as verified by the unit's flame detector), then the unit shut down. An alarm alerted the operator that flame was not detected. In accordance with Technical Procedure (TPR) -1628, VVET Unit Startup, Operations, and Shutdown," the operator reset the alarm and initiated a start by pressing the preheater start button. The unit then completed another 5-minute preheat purge and again attempt to ignite the pilot light.

It was determined that consecutive multiple 5-minute purges were not necessary for compliance with requirements. Modification of the ladder logic reduces time required to start a unit, particularly in cold weather, with no increased hazards.

2.7.1.1.2 Notify Operator Before Completion of Preheat Purge Cycle. The amber preheater purging indicator light will provide the operator with a 10-second warning that the preheat purge cycle is almost complete by flashing during the last 10 seconds of the preheat purging cycle. This change will aid the technician by alerting the technician that process parameters and control devices associated with the preheater pilot flame ignition try and preheat mode soon will need to be monitored in accordance with TPR-1628.

2.7.1.1.3 Eliminate Spurious Shutdowns Associated with Pressure Switches. High-pressure propane Switches PSHH-221 and -222 sometimes needlessly caused system shutdowns during startup operations. Sometimes, on opening the block valve, a momentary pressure wave was created to which the corresponding pressure switch reacted to shut the unit down. The change installed a timer so that a switch must be in a high-pressure condition for 5 seconds before the unit is shut down. This change will prevent spurious shutdowns caused by pressure waves.

2.7.1.1.4 Eliminate Temperature High and Low Alarm Nuisance Alarms. The previous existing ladder logic written for Units A and B set a high-temperature (TEMPHI) alarm if any temperature element exceeded the high alarm setpoint. The low-temperature (TEMPLO) alarm is set if any temperature element drops below the low setpoint during the profile or run mode. If a momentary change occurs in the temperature element, then the TEMPHI or TEMPLO alarm could be set. Modification to the ladder logic for the units will require that the TEMPHI or TEMPLO alarms have been set for at least 10 seconds to ensure a true alarm condition before an alarm is indicated.

2.7.1.1.5 Eliminate Automatic Mode Rollover. Previously, if the preheater stop button was pushed before the oxidizer temperatures reached predetermined values, then the unit would not switch into profile mode. However, the unit would automatically switch to profile mode when all of the temperatures were at or above the predetermined values. Conduct of operations considerations demand that the technician be at the unit when it changes to profile mode. Therefore, the software was changed so that the unit will switch to profile mode when the preheater stop button is pushed and oxidizer minimum temperature requirements are met.

2.7.1.1.6 Adjustments to the Valve Actuation-Related Timer. Under a separate engineering change form, Flow Control Valve (FCV) -210 was changed out with a valve equipped with a larger but slower positioner. The new valve takes longer both to open and close. The valve is equipped with valve-position transmitters connected to the PLC. The time allowances for valve opening and closing timers needed to be lengthened. Related timers (e.g., time allowed for the blower to start) were evaluated and changed where appropriate.

2.7.1.1.7 Standardize the Low Process-Flow-Alarm Value. Previously, multiple timer and alarm points were in place for process flow to the oxidizer. Various timer and alarm points were associated with different operational modes. Process flows were affected by a flow orifice that was removed under a previous engineering change form. The software was changed to invoke an alarm condition if the flow falls below 250 cfm for 30 seconds.

2.7.1.1.8 Alarm Alert Modification. This change caused control panel alarm indicator Light ZAL-341 to flash during the first 30 seconds of a preheat purge cycle if propane FCV-341 is not in the minimum-fire position as indicated by limit Switch ZSL-341. This change alerts the operator to use

TPR-1628 to adjust the position of FCV-341. If the valve is not in the proper position after 30 seconds into a preheat purge cycle, then the unit will be automatically shut down.

2.7.2 Preventive Maintenance

A preventive maintenance schedule has been developed to ensure that appropriate measures are taken to maximize the life of system components. The preventive maintenance schedule identifies maintenance activities to be completed at monthly, quarterly, semiannual, annual, and biannual intervals (McMurtrey and Harvego 2001). Maintenance work is planned by project field personnel and executed by RWMC craft personnel. Development and implementation of preventive maintenance work packages are in conformance with the INEEL "Integrated Work Control Process" (STD-101). Project field personnel continue to make improvements on the maintenance work packages to minimize downtime of the VVET units.

During the 2002 end-year reporting cycle, all preventive maintenance work was performed on schedule. Monthly preventive maintenance tasks were performed on Units A, B, and D from July through December 2002. Quarterly preventive maintenance tasks were performed on Unit D in July, September, and December 2002. Semiannual preventive maintenance tasks were performed on Unit D in December 2002. The semiannual and annual preventive maintenance tasks on Units A and B were performed in October 2002.

2.7.3 Configuration Management

The configuration management process provides quick access to a database of information about individual components and pieces of equipment including the manufacturer model and serial numbers, contact address and phone numbers, and all pertinent information for repairing or replacing any component or part. The database also provides a numbering system to identify the equipment and components in the field when performing preventive maintenance or other work activities.

2.7.4 Calibration Program

Calibration is performed on system process indicators in accordance with the INEEL "Control of Measuring and Test Equipment" (MCP-2391). The process indicators, including switches, gauges, transducers, and controllers, are calibrated to ensure proper function. Gauges, switches, and transducers are tested, calibrated, and retained in controlled storage at the RWMC before installation during scheduled preventive maintenance activities.

2.7.5 Well-Drilling Activities

Well-drilling activities began at the RWMC during the end-year 2002 operational period. Wells IE6, IE7 and IE8 were drilled to the 33.5-m (110-ft) bgs interbed and were set with casing and vapor ports. Well SE8 was drilled to 41.5 m (136 ft) bgs. Wells DE6 and DE7 were drilled to approximately 68.6 m (255 ft) bgs and casing and vapor ports were set in Well DE6.

The well-installation project is expected to last through Fiscal Year 2003 and consists of drilling, constructing, and installing 15 wells. All boreholes will be completed as extraction and monitoring wells. The deep extraction and monitoring wells will have vapor ports for monitoring vapor concentrations. For a complete discussion of activities I (e.g., locations, descriptions, and materials), refer to the *Statement of Work for Operable Unit 7-08 Monitoring and Extraction Well Installations* (INEEL 2002).

2.8 Operational Uptime

During the end-year 2002 operations period, a goal of 80% uptime of available hours was set for operation of the VVET units including planned downtime for maintenance activities. Units A, B, and D achieved uptimes of 100, 97.5, and 99.7% of available hours, respectively. Appendix E contains the operations history of VVET Units A, B, C, and D.

2.8.1 Planned and Uncontrollable Downtime

Available hours equals calendar hours less planned and uncontrollable downtimes. The majority of downtimes occurring during the end-year 2002 operations period were classified as planned or uncontrollable downtimes. Planned downtimes included scheduled maintenance activities (corrective and preventive) and system optimizations. Uncontrollable downtimes were the result of natural causes (e.g., electrical outages).

Brief explanations of activities that resulted in planned or uncontrollable operational shutdowns are itemized in this section.

- July 3, 2002—Quarterly preventive maintenance performed on Unit D.
- July 11 through July 16, 2002—A power outage occurred at the RWMC. A sectionalizer fuse had blown. Units A and D were restarted on July 15. Unit B was restarted the following day.
- July 17 through August 2, 2002—A fuse blew on the pole supplying power to Units A and D. Unit D shut down on July 17 and Unit A shut down on July 18. Unit B continued to run. Unit B was shut down briefly for a planned power outage on August 1 to repair the electrical system. Units A, B, and D were restarted on August 2.
- August 13, 2002—Unit A was shut down to perform a lockout and tagout requirement to remove Pipeline 4E.
- September 18, 2002—Unit D was shut down briefly to perform a quarterly preventive maintenance.
- October 8, 2002—A Central Facilities Area substation power loss resulted in shutdown of all three units for a brief time during October 8.
- October 22 through October 30, 2002—Semiannual and annual preventive maintenance.
- November 7, 2002—Checked new belt tension, loaded revised software.
- October 22 through October 29, 2002—Semiannual and annual preventive maintenance activities required the shutdown of Units A and B.
- November 6, 2002—Unit B was shut down to check new belt tension and load revised PLC software.
- November 7, 2002—Unit A was shut down to check new belt tension and load revised PLC software.
- December 3, 2002—Unit D was shut down for quarterly and semiannual preventive maintenance.

2.8.2 Unplanned Downtime

Through the operational period, Unit A had no downtime categorized as unplanned. Unit B recorded unplanned downtimes of 2.5% (100.1 hours) and Unit D 0.3% (11.52 hours) of available hours. Equipment failures that led to unplanned operational shutdown are itemized below:

- June 16 through July 2, 2002—Operation of Unit B was interrupted on June 16, 2002, when the RWMC off-shift surveillance identified problems with the propane vaporizer. Suburban Propane personnel performed limited troubleshooting and removed the vaporizer for servicing. The vaporizer was reinstalled and Unit B was restarted on July 2, 2002.

- November 20 through November 20, 2002—Operation of Unit D was interrupted on November 20, 2002, because of a broken blower belt. The belt was replaced and Unit D was restarted later that same day.

- December 24, 2002—Operation of Unit B was interrupted on December 24, 2002, because of a propane system problem. The Unit B propane burner was cleaned and the unit restarted that same day.

- December 25 through December 28, 2002—Operation of Unit B was interrupted on December 25, 2002, because of propane system problems. Propane lines, check valves, and the sparger were cleaned. Unit B was restarted on December 28, 2002.

3. CONCLUSION

Data quality and monitoring objectives include completeness, precision, and accuracy as outlined in the OCVZ DQO report. The target for completeness was generally met. Issues affecting instrument analytical accuracy and precision have been identified and corrected. To date, Units A, B, and D are operating and removing VOC mass from the RWMC subsurface. According to samples collected from various locations around the SDA, VOC concentrations are decreasing above the 34-m (110-ft) interbed.

4. REFERENCES

42 USC § 9601 et seq., 1980, "Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA/Superfund)," *United States Code*.

DOE-ID, 1991, *Federal Facility Agreement and Consent Order for the Idaho National Engineering Laboratory,* Administrative Record No. 1088-06-29-120, U.S. Department of Energy Operations Office; U.S. Environmental Protection Agency, Region 10; Idaho Department of Health and Welfare.

DOE-ID, 1994, *Record of Decision: Declaration for Organic Contamination in the Vadose Zone Operable Unit 7-08, Idaho National Engineering Laboratory, Radioactive Waste Management Complex, Subsurface Disposal Area*, Administrative Record No. 5761, U.S. Department of Energy Idaho Operations Office; U.S. Environmental Protection Agency, Region 10; Idaho Department of Health and Welfare.

EDF-2157, 2002, "Mass Removal Calculation Using Process Sampling Data for Operable Unit 7-08, Organic Contamination in the Vadose Zone," Rev. 0.

EDF-2594, 2002, "Pilot Light Ignition Retry with Reduced Purge Time," Rev. 0.

INEEL, 2002, *Data Quality Objectives Summary Report for Operable Unit 7-08 Post-Record of Decision Sampling*, INEEL/EXT-2000-00814, Rev. 1, Idaho National Engineering and Environmental Laboratory, Bechtel BWXT Idaho, LLC, Idaho Falls, Idaho.

MCP-2391, 2002, "Control of Measuring and Test Equipment," Rev. 5.

McMurtrey, Ryan, and Lisa A. Harvego, 2001, *Operations and Maintenance Plan for Operable Unit 7-08, Organic Contamination in the Vadose Zone*, INEEL/EXT-2001-00016, Rev. 0, Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho.

STD-101, 2001, "Integrated Work Control Process," Rev. 12, Operations, September 19, 2001.

TPR-1628, 2002, "VVET Unit Startup, Operations, and Shutdown," Rev. 7.

Appendix A

Sampling Precision

Appendix A

Sampling Precision

To calculate mass removal rates of volatile organic compound and to monitor effectiveness of the vapor vacuum extraction with treatment system at the Subsurface Disposal Area, vapor samples were collected at the inlet of the vapor vacuum extraction with treatment units and analyzed using a Brüel and Kjær (B&K) photoacoustic multigas analyzer. Tables A-1 and A-2 show the sample precision of duplicate or repeat samples of chloroform, 1,1,1-trichloroethane, tetrachloroethylene, trichloroethylene, carbon tetrachloride, and total volatile organic compounds for the year-end 2002 operational period.

Table A-1. Monthly vapor sample precision—repeats.

	12:01:29	8.92E-01	2.06E+00	1.30E+00	1.20E+00	1.29E+00	2.99E+03
	12:04:29	1.08E+00	2.09E+00	1.30E+00	1.11E+00	1.03E+00	3.02E+03
RPD		19.07%	1.45%	0.00%	7.79%	22.41%	1.00%
	12:26:32	2.44E+00	1.06E+00	8.17E-01	3.73E+00	8.28E+00	1.10E+04
	12:29:01	1.79E+00	8.60E-01	6.32E-01	2.06E+00	4.83E+00	1.11E+04
RPD		30.73%	20.83%	25.53%	57.69%	52.63%	0.90%
	12:50:05	2.13E+00	5.26E-01	3.08E-01	5.70E-01	4.53E-01	1.21E+04
	12:52:52	2.27E+00	6.16E-01	2.76E-01	5.94E-01	4.37E-01	1.21E+04
RPD		6.36%	15.76%	10.96%	4.12%	3.60%	0.00%
	13:07:10	1.03E+01	6.29E+00	2.68E+00	1.12E+01	2.53E+01	1.26E+04
	13:09:36	1.02E+01	6.19E+00	2.50E+00	1.09E+01	2.43E+01	1.26E+04
RPD		0.98%	1.60%	6.95%	2.71%	4.03%	0.00%
	13:16:33	9.64E+00	9.47E+00	2.87E+00	6.02E+00	4.61E+01	1.27E+04
	13:18:48	9.82E+00	9.55E+00	2.86E+00	6.10E+00	4.65E+01	1.28E+04
RPD		1.85%	0.84%	0.35%	1.32%	0.86%	0.78%
	14:16:52	1.47E+01	1.02E+01	3.01E+00	2.02E+01	9.23E+01	1.26E+04
	14:19:02	1.33E+01	9.21E+00	2.70E+00	1.82E+01	8.30E+01	1.28E+04
RPD		10.00%	10.20%	10.86%	10.42%	10.61%	1.57%
	14:33:22	1.64E+00	3.77E-01	1.60E-01	9.11E-01	6.11E-01	1.25E+04
	14:35:37	1.84E+00	3.80E-01	1.88E-01	7.03E-01	4.24E-01	1.25E+04
RPD		11.49%	0.79%	16.09%	25.77%	36.14%	0.00%
	12:24:16	3.10E+00	4.23E+00	1.27E+00	4.40E+00	1.31E+01	1.22E+04
	12:26:35	3.06E+00	4.21E+00	1.35E+00	4.43E+00	1.32E+01	1.22E+04
RPD		1.30%	0.47%	6.11%	0.68%	0.76%	0.00%
	12:49:28	4.00E+00	2.53E+00	8.64E-01	2.79E+00	8.21E+00	1.23E+04
	12:52:13	3.90E+00	2.56E+00	8.27E-01	2.83E+00	8.25E+00	1.24E+04
RPD		2.53%	1.18%	4.38%	1.42%	0.49%	0.81%
	13:44:17	1.79E+00	4.08E-01	9.84E+00	7.25E-01	-8.99E-01	1.26E+04
	13:46:26	1.79E+00	3.50E-01	9.86E+00	7.10E-01	-8.95E-01	1.26E+04
RPD		0.00%	15.30%	0.20%	2.09%	0.00%	0.00%
	13:55:44	2.60E+00	1.65E+00	1.71E+00	6.48E-01	3.92E+00	1.26E+04
	13:57:56	2.65E+00	1.65E+00	1.71E+00	6.14E-01	3.91E+00	1.26E+04
RPD		1.90%	0.00%	0.00%	5.39%	0.26%	0.00%
	14:31:12	6.73E+00	7.11E+00	2.28E+00	8.43E+00	2.87E+01	1.31E+04

Table A-1. (continued).

Sample Repeats	Time	$CHCl_3$ (ppmv)	TCA (ppmv)	PCE (ppmv)	TCE (ppmv)	CCl_4 (ppmv)	H_2O (ppmv)
	14:33:34	6.46E+00	7.12E+00	2.12E+00	7.85E+00	2.75E+01	1.32E+04
RPD		4.09%	0.14%	7.27%	7.13%	4.27%	0.76%
	14:43:08	2.01E+00	1.14E+00	7.22E-01	3.17E+00	6.73E+00	1.33E+04
	14:45:35	1.55E+00	9.96E-01	5.28E-01	1.81E+00	3.62E+00	1.34E+04
RPD		25.84%	13.48%	31.04%	54.62%	60.10%	0.75%
	15:38:51	8.91E+00	9.99E+00	3.59E+00	1.11E+01	5.52E+01	1.29E+04
	15:41:22	9.00E+00	9.99E+00	3.53E+00	1.12E+01	5.54E+01	1.29E+04
RPD		1.01%	0.00%	1.69%	0.90%	0.36%	0.00%
	15:54:52	4.80E+00	2.22E+00	7.97E-01	1.95E+00	5.06E+00	1.28E+04
	15:57:04	4.87E+00	2.28E+00	7.83E-01	1.88E+00	5.01E+00	1.29E+04
RPD		1.45%	2.67%	1.77%	3.66%	0.99%	0.78%
	13:18:35	1.22E+00	4.65E-01	3.07E-01	1.37E+00	3.17E+00	1.08E+04
	13:20:58	8.30E-01	4.44E-01	2.63E-01	5.40E-01	8.82E-01	1.08E+04
RPD		38.05%	4.62%	15.44%	86.91%	112.93%	0.00%
	13:46:22	1.82E+00	6.17E-01	2.09E-01	2.97E-01	4.72E-01	1.06E+04
	13:48:38	1.81E+00	6.25E-01	1.72E-01	3.11E-01	4.05E-01	1.07E+04
RPD		0.55%	1.29%	19.42%	4.61%	15.28%	0.94%
	14:33:19	2.87E+00	1.74E+00	6.07E-01	2.03E+00	5.61E+00	1.04E+04
	14:35:32	2.99E+00	1.91E+00	6.44E-01	2.03E+00	5.69E+00	1.04E+04
RPD		4.10%	9.32%	5.92%	0.00%	1.42%	0.00%
	15:06:00	2.96E+00	1.86E+00	6.05E-01	1.89E+00	6.05E+00	1.02E+04
	15:08:12	3.02E+00	1.84E+00	6.01E-01	2.00E+00	5.99E+00	1.02E+04
RPD		2.01%	1.08%	0.66%	5.66%	1.00%	0.00%
	15:26:30	1.82E+00	5.12E-01	1.16E-01	9.45E-02	3.03E-02	1.01E+04
	15:28:43	1.78E+00	3.48E-01	1.27E-01	1.08E-01	5.11E-02	1.01E+04
RPD		2.22%	38.14%	9.05%	13.33%	51.11%	0.00%
	13:02:47	1.60E+00	1.79E+00	8.07E-01	1.33E+00	4.70E+00	1.23E+04
	13:05:00	1.57E+00	1.59E+00	7.23E-01	1.12E+00	4.15E+00	1.24E+04
RPD		1.89%	11.83%	10.98%	17.14%	12.43%	0.81%
	13:14:18	3.37E+00	2.33E+00	9.88E-01	2.86E+00	8.06E+00	1.24E+04
	13:17:06	3.27E+00	2.25E+00	9.47E-01	2.84E+00	7.85E+00	1.26E+04
RPD		3.01%	3.49%	4.24%	0.70%	2.64%	1.60%
	13:37:55	1.84E+00	1.21E+00	4.43E-01	5.37E-01	2.52E+00	1.25E+04
	13:40:12	1.93E+00	1.16E+00	4.35E-01	4.32E-01	2.50E+00	1.26E+04
RPD		4.77%	4.22%	1.82%	21.67%	0.80%	0.80%

Table A-1. (continued).

Sample Repeats		$CHCl_3$	TCA	PCE	TCE	CCl_4	H_2O
	14:22:11	2.18E+00	6.04E-01	1.54E-01	9.04E-02	-9.30E-03	1.23E+04
	14:24:24	2.18E+00	5.55E-01	8.85E-02	1.40E-01	-2.20E-02	1.24E+04
RPD		0.00%	8.46%	54.02%	43.06%	0.00%	0.81%
	13:19:43	1.38E+00	9.49E-01	6.88E-01	7.68E-01	1.34E+00	1.23E+04
	13:22:18	1.26E+00	9.51E-01	6.92E-01	6.81E-01	1.35E+00	1.23E+04
RPD		9.09%	0.21%	0.58%	12.01%	0.74%	0.00%
	13:43:10	6.92E-01	5.42E-01	2.83E-01	8.45E-02	7.71E-02	1.26E+04
	13:45:23	6.34E-01	4.15E-01	2.85E-01	1.06E-01	9.66E-02	1.20E+04
RPD		8.75%	26.54%	0.70%	22.57%	22.45%	4.88%
	13:49:49	6.28E-01	5.00E-01	2.50E-01	1.39E-01	3.34E-01	1.26E+04
	13:52:21	6.47E-01	5.02E-01	2.12E-01	1.79E-01	3.04E-01	1.26E+04
RPD		2.98%	0.40%	16.45%	25.16%	9.40%	0.00%
	14:10:19	1.18E+00	1.43E+00	3.95E-01	9.30E-01	3.05E+00	1.26E+04
	14:13:04	1.28E+00	1.20E+00	3.65E-01	9.12E-01	3.08E+00	1.27E+04
RPD		8.13%	17.49%	7.89%	1.95%	0.98%	0.79%
	13:03:57	9.18E+01	2.56E+01	9.64E+00	8.98E+01	2.74E+02	1.16E+04
	13:06:21	9.25E+01	2.58E+01	9.63E+00	9.14E+01	2.78E+02	1.16E+04
RPD		0.76%	0.78%	0.10%	1.77%	1.45%	0.00%
	14:04:48	5.38E+00	2.69E+00	1.18E+00	2.57E+00	5.60E+00	1.34E+04
	14:07:07	5.31E+00	2.58E+00	1.01E+00	2.21E+00	4.84E+00	1.35E+04
RPD		1.31%	4.17%	15.53%	15.06%	14.56%	0.74%
	14:23:07	5.06E+00	3.24E+00	1.52E+00	2.87E+00	7.29E+00	1.19E+04
	14:25:20	5.19E+00	3.14E+00	1.33E+00	2.85E+00	7.34E+00	1.19E+04
RPD		2.54%	3.13%	13.33%	0.70%	0.68%	0.00%
	10:38:16	1.75E+00	6.40E-01	1.06E+00	9.02E-01	6.25E-01	1.30E+04
	10:41:00	1.62E+00	6.94E-01	1.15E+00	8.83E-01	6.39E-01	1.31E+04
RPD		7.72%	8.10%	8.14%	2.13%	2.22%	0.77%
	11:11:40	1.11E+00	4.05E-01	3.09E-01	8.76E-01	7.54E-01	1.26E+04
	11:13:51	1.01E+00	4.31E-01	3.60E-01	8.09E-01	6.31E-01	1.26E+04
RPD		9.43%	6.22%	15.25%	7.95%	17.76%	0.00%
	9:49:37	1.15E+00	5.14E-01	3.19E-01	3.47E-01	6.69E-01	8.13E+03
	9:52:23	1.36E+00	4.75E-01	2.31E-01	3.26E-01	5.62E-01	8.11E+03
RPD		16.73%	7.89%	32.00%	6.24%	17.38%	0.25%
	10:13:20	2.31E+00	1.06E+00	1.33E-01	1.13E-01	6.08E-02	8.03E+03
	10:15:35	2.58E+00	1.12E+00	1.16E-01	6.18E-02	1.50E-03	8.01E+03

Table A-1. (continued).

Sample Repeats	Time	$CHCl_3$ (ppmv)	TCA (ppmv)	PCE (ppmv)	TCE (ppmv)	CCl_4 (ppmv)	H_2O (ppmv)
RPD		11.04%	5.50%	13.65%	58.58%	190.37%	0.25%
	10:45:53	2.83E+00	2.22E+00	9.67E-01	2.69E+00	6.75E+00	8.08E+03
	10:48:06	2.88E+00	2.10E+00	9.50E-01	2.77E+00	6.77E+00	8.07E+03
RPD		1.75%	5.56%	1.77%	2.93%	0.30%	0.12%
	11:20:10	3.28E+00	1.14E+00	6.58E-02	9.95E-02	-1.37E-01	7.82E+03
	11:22:53	3.47E+00	1.09E+00	5.68E-02	8.75E-02	-1.89E-01	7.86E+03
RPD		5.63%	4.48%	14.68%	12.83%	0.00%	0.51%
	11:25:04	3.19E+01	1.52E+01	5.35E+00	3.74E+01	1.17E+02	8.20E+03
	11:29:41	3.17E+01	1.51E+01	5.28E+00	3.75E+01	1.16E+02	8.26E+03
RPD		0.63%	0.66%	1.32%	0.27%	0.86%	0.73%
	9:43:33	1.39E+00	6.05E-01	2.80E-01	5.34E-01	7.95E-01	8.29E+03
	9:45:48	1.24E+00	6.62E-01	4.15E-01	5.65E-01	9.04E-01	8.33E+03
RPD		**11.41%**	**9.00%**	**38.85%**	**5.64%**	**12.83%**	**0.48%**
	10:04:36	7.22E+00	5.13E+00	1.90E+00	8.41E+00	2.12E+01	8.11E+03
	10:06:51	7.12E+00	5.12E+00	1.89E+00	8.30E+00	2.08E+01	8.14E+03
RPD		1.39%	0.20%	0.53%	1.32%	1.90%	0.37%
	10:32:16	4.27E+00	3.83E+00	9.07E+00	1.16E+00	2.41E+00	8.29E+03
	10:34:27	4.32E+00	3.90E+00	9.41E+00	1.10E+00	2.41E+00	8.29E+03
RPD		1.16%	1.81%	3.68%	5.31%	0.00%	0.00%
	11:06:36	1.85E+01	6.31E+00	1.20E+00	1.53E+01	7.49E+01	8.07E+03
	11:08:50	1.87E+01	6.40E+00	1.20E+00	1.54E+01	7.59E+01	8.08E+03
RPD		1.08%	1.42%	0.00%	0.65%	1.33%	0.12%
	14:24:32	1.64E+00	3.80E-01	3.10E+01	2.03E+00	2.83E-01	1.33E+04
	14:26:49	8.26E-02	4.02E-01	6.67E-01	2.94E-01	4.45E-01	7.45E+03
RPD		180.82%	5.63%	191.57%	149.40%	44.51%	56.39%
	14:29:19	3.86E+00	-3.30E+00	1.79E+02	1.19E+01	-9.90E+00	1.14E+04
	14:31:36	3.89E+00	-3.30E+00	1.78E+02	1.19E+01	-9.90E+00	1.15E+04
RPD		0.77%	0.00%	0.56%	0.00%	0.00%	0.87%
	14:36:15	1.76E+00	1.14E+00	6.69E-01	7.11E-01	2.29E+00	1.21E+04
	14:39:04	1.62E+00	1.32E+00	6.31E-01	7.51E-01	2.69E+00	1.15E+04
RPD		8.28%	14.63%	5.85%	5.47%	16.06%	5.08%
	14:59:50	1.88E+00	1.44E+00	6.18E-01	1.70E+00	3.86E+00	1.21E+04
	15:02:06	1.81E+00	1.37E+00	6.51E-01	1.65E+00	3.84E+00	1.19E+04
RPD		3.79%	4.98%	5.20%	2.99%	0.52%	1.67%
	15:11:32	1.21E+00	3.61E-01	2.32E-01	3.01E-01	3.46E-01	1.05E+04

Table A-1. (continued).

Sample Repeats	Time	$CHCl_3$ (ppmv)	TCA (ppmv)	PCE (ppmv)	TCE (ppmv)	CCl_4 (ppmv)	H_2O (ppmv)
	15:13:43	1.29E+00	3.32E-01	2.39E-01	2.55E-01	3.50E-01	1.03E+04
RPD		6.40%	8.37%	2.97%	16.55%	1.15%	1.92%
	9:52:49	7.42E+01	2.29E+01	7.74E+00	7.75E+01	2.62E+02	5.71E+03
	9:55:30	7.53E+01	2.32E+01	7.69E+00	7.94E+01	2.66E+02	5.66E+03
RPD		1.47%	1.30%	0.65%	2.42%	1.52%	0.88%
	10:17:25	1.09E+01	6.64E+00	2.21E+00	9.06E+00	2.51E+01	5.61E+03
	10:19:43	1.10E+01	6.71E+00	2.22E+00	9.14E+00	2.52E+01	5.66E+03
RPD		0.91%	1.05%	0.45%	0.88%	0.40%	0.89%
	10:40:47	2.30E+00	6.03E-01	4.66E-01	4.72E-01	5.37E-01	5.60E+03
	10:43:01	2.39E+00	5.37E-01	3.92E-01	4.63E-01	3.62E-01	5.62E+03
RPD		3.84%	11.58%	17.25%	1.93%	38.93%	0.36%
	11:35:43	1.00E+01	8.17E+00	2.92E+00	2.84E+01	5.77E+01	6.32E+03
	11:37:59	1.00E+01	8.07E+00	3.01E+00	2.86E+01	5.82E+01	6.30E+03
RPD		0.00%	1.23%	3.04%	0.70%	0.86%	0.32%
	12:12:26	3.11E+00	3.37E+00	7.88E-01	1.36E+00	2.70E+00	7.32E+03
	12:14:38	3.32E+00	3.22E+00	6.74E-01	1.38E+00	2.58E+00	7.31E+03
RPD		6.53%	4.55%	15.60%	1.46%	4.55%	0.14%
	14:28:56	1.33E+00	3.81E+00	5.70E-01	6.46E-01	5.32E-01	1.11E+04
	14:31:15	1.49E+00	3.95E+00	6.39E-01	6.67E-01	5.18E-01	1.11E+04
RPD		11.35%	3.61%	11.41%	3.20%	2.67%	0.00%
	14:48:18	2.27E+01	6.39E+00	1.01E+00	1.73E+01	4.02E+01	9.87E+03
	14:50:33	2.29E+01	6.23E+00	1.02E+00	1.73E+01	4.02E+01	9.86E+03
RPD		0.88%	2.54%	0.99%	0.00%	0.00%	0.10%
	15:16:44	1.49E+00	3.02E+00	2.54E-01	1.02E+00	6.48E-01	9.23E+03
	15:18:55	1.60E+00	2.76E+00	2.24E-01	9.76E-01	5.98E-01	9.18E+03
RPD		7.12%	9.00%	12.55%	4.41%	8.03%	0.54%
	8:29:26	3.70E+00	3.45E+00	2.37E+00	3.34E+00	6.14E+00	6.87E+03
	8:31:41	3.80E+00	3.42E+00	2.18E+00	3.28E+00	6.08E+00	6.86E+03
RPD		2.67%	0.87%	8.35%	1.81%	0.98%	0.15%
	8:57:27	1.99E+00	1.71E+00	5.81E-01	1.18E+00	9.51E-01	6.79E+03
	8:59:42	1.99E+00	1.56E+00	5.56E-01	9.44E-01	6.85E-01	6.79E+03
RPD		0.00%	9.17%	4.40%	22.22%	32.52%	0.00%
	9:23:10	5.21E+00	1.06E+01	1.74E+00	4.25E+00	6.62E+00	6.92E+03
	9:25:42	5.21E+00	1.06E+01	1.80E+00	4.30E+00	6.67E+00	6.90E+03
RPD		0.00%	0.00%	3.39%	1.17%	0.75%	0.29%

Table A-1. (continued).

Sample Repeats	Time	$CHCl_3$ (ppmv)	TCA (ppmv)	PCE (ppmv)	TCE (ppmv)	CCl_4 (ppmv)	H_2O (ppmv)
	9:48:31	8.49E+01	2.94E+01	8.63E+00	9.93E+01	3.56E+02	7.18E+03
	9:50:55	8.54E+01	2.94E+01	8.83E+00	1.01E+02	3.59E+02	7.20E+03
RPD		0.59%	0.00%	2.29%	1.70%	0.84%	0.28%
	10:19:54	7.33E+00	7.19E+00	2.19E+00	8.83E+00	2.52E+01	7.19E+03
	10:22:06	7.48E+00	6.89E+00	2.23E+00	8.93E+00	2.54E+01	7.22E+03
RPD		2.03%	4.26%	1.81%	1.13%	0.79%	0.42%
	10:48:21	2.44E+00	1.96E+00	2.05E-01	3.95E-01	1.65E+00	7.35E+03
	10:50:33	2.56E+00	1.70E+00	1.72E-01	3.35E-01	1.62E+00	7.36E+03
RPD		4.80%	14.21%	17.51%	16.44%	1.83%	0.14%
	11:54:09	3.18E+00	7.87E+00	1.77E-01	1.61E+00	2.30E+00	8.16E+03
	11:56:19	3.23E+00	7.82E+00	2.52E-01	1.52E+00	2.31E+00	8.24E+03
RPD		1.56%	0.64%	34.97%	5.75%	0.43%	0.98%
	12:18:46	3.32E+00	4.30E+00	2.91E-01	1.28E+00	3.05E+00	8.52E+03
	12:20:56	3.36E+00	4.15E+00	2.77E-01	1.37E+00	3.08E+00	8.56E+03
RPD		1.20%	3.55%	4.93%	6.79%	0.98%	0.47%
	12:44:24	3.65E+00	5.90E+00	4.48E-01	1.65E+00	4.83E+00	8.85E+03
	12:46:34	3.58E+00	5.35E+00	4.86E-01	1.66E+00	4.80E+00	8.93E+03
RPD		1.94%	9.78%	8.14%	0.60%	0.62%	0.90%
	13:08:48	2.55E+00	2.94E+00	9.86E-02	6.50E-01	5.44E-01	9.10E+03
	13:10:58	2.72E+00	2.72E+00	1.32E-01	5.45E-01	5.21E-01	9.13E+03
		6.45%	7.77%	28.97%	17.57%	4.32%	0.33%

$CHCl_3$ = chloroform
CCl_4 = carbon tetrachloride
H_2O = water
PCE = tetrachlorethylene
RPD = relative percent difference
TCA = trichloroethane
TCE = trichoroethylene

Table A-2. Monthly vapor sample precision—duplicates.

	12:29:01	1.79E+00	8.60E-01	6.32E-01	2.06E+00	4.83E+00	1.11E+04
	12:31:36	2.60E+00	8.65E-01	5.91E-01	1.92E+00	3.82E+00	1.18E+04
RPD		36.90%	0.58%	6.70%	7.04%	23.35%	6.11%
	13:09:36	1.02E+01	6.19E+00	2.50E+00	1.09E+01	2.43E+01	1.26E+04
	13:12:01	8.94E+00	6.34E+00	2.72E+00	1.20E+01	2.62E+01	1.25E+04
RPD		13.17%	2.39%	8.43%	9.61%	7.52%	0.80%
	14:07:27	4.82E+00	1.18E+00	2.91E-01	2.24E+00	5.34E+00	1.32E+04
	14:09:41	2.04E+01	4.37E+00	7.79E-01	1.30E+01	3.34E+01	1.24E+04
RPD		123.55%	114.95%	91.21%	141.21%	144.86%	6.25%
	12:33:41	3.09E+00	2.17E+00	8.64E-01	2.20E+00	4.93E+00	1.23E+04
	12:35:54	3.01E+00	2.12E+00	8.90E-01	2.08E+00	4.79E+00	1.24E+04
RPD		2.62%	2.33%	2.96%	5.61%	2.88%	0.81%
	13:16:59	2.23E+00	1.64E+00	3.04E-01	2.74E-01	1.16E-01	1.24E+04
	13:19:12	2.78E+00	1.71E+00	3.02E-01	2.27E-01	-1.13E-01	1.25E+04
RPD		21.96%	4.18%	0.66%	18.76%	0.00%	0.80%
	13:50:48	2.94E+00	2.43E+00	6.90E-01	1.41E+00	5.38E+00	1.27E+04
	13:53:32	2.45E+00	1.62E+00	4.47E-01	8.88E-01	3.48E+00	1.26E+04
RPD		18.18%	40.00%	42.74%	45.43%	42.89%	0.79%
	14:45:35	1.55E+00	9.96E-01	5.28E-01	1.81E+00	3.62E+00	1.34E+04
	14:47:50	1.83E+00	7.86E-01	5.47E-01	1.75E+00	4.02E+00	1.32E+04
RPD		16.57%	23.57%	3.53%	3.37%	10.47%	1.50%
	15:27:15	8.19E+00	5.70E+00	2.21E+00	9.74E+00	2.38E+01	1.30E+04
	15:29:27	7.59E+00	5.90E+00	2.25E+00	9.68E+00	2.50E+01	1.31E+04
RPD		7.60%	3.45%	1.79%	0.62%	4.92%	0.77%
	13:06:48	2.01E+01	6.23E+00	1.51E+00	1.62E+01	6.06E+01	1.09E+04
	13:09:06	1.84E+01	5.71E+00	1.32E+00	1.47E+01	5.60E+01	1.09E+04
RPD		8.83%	8.71%	13.43%	9.71%	7.89%	0.00%
	13:57:38	1.91E+00	1.80E+00	5.83E-01	1.38E+00	5.00E+00	1.07E+04
	13:59:49	1.48E+00	1.28E+00	3.48E-01	9.43E-01	3.58E+00	1.06E+04
RPD		25.37%	33.77%	50.48%	37.62%	33.10%	0.94%
	14:45:30	2.82E+00	3.95E+00	1.08E+00	4.07E+00	1.20E+01	1.03E+04
	14:47:45	6.06E+00	5.41E+00	1.08E+00	4.43E+00	1.27E+01	1.04E+04
RPD		72.97%	31.20%	0.00%	8.47%	5.67%	0.97%
	14:54:35	2.24E+00	1.31E+00	2.91E-01	2.95E-01	1.14E-01	1.03E+04

Table A-2. (continued).

Sample Duplicates	Time	$CHCl_3$ (ppmv)	TCA (ppmv)	PCE (ppmv)	TCE (ppmv)	CCl_4 (ppmv)	H_2O (ppmv)
	14:56:45	2.48E+00	1.27E+00	2.77E-01	2.46E-01	-1.90E-02	1.02E+01
RPD		10.17%	3.10%	4.93%	18.11%	0.00%	199.60%
	13:00:33	2.28E+00	1.91E+00	9.11E-01	9.45E-01	2.51E+00	1.24E+04
	13:02:47	1.60E+00	1.79E+00	8.07E-01	1.33E+00	4.70E+00	1.23E+04
RPD		35.05%	6.49%	12.11%	33.85%	60.75%	0.81%
	13:21:39	1.51E+00	6.42E-01	2.89E-01	2.16E-01	9.36E-02	1.30E+04
	13:23:51	1.59E+00	6.84E-01	2.83E-01	2.09E-01	2.07E-02	1.30E+04
RPD		5.16%	6.33%	2.10%	3.29%	127.56%	0.00%
	13:31:26	7.82E+00	2.79E+00	6.56E-01	1.35E+00	3.09E+00	1.45E+04
	13:33:42	3.02E+00	1.84E+00	6.39E-01	1.37E+00	3.81E+00	1.48E+04
RPD		88.56%	41.04%	2.63%	1.47%	20.87%	2.05%
	13:18:28	1.01E+01	6.80E+00	3.48E+00	1.38E+01	4.18E+01	1.14E+04
	13:20:42	1.10E+01	6.86E+00	3.65E+00	1.39E+01	4.19E+01	1.17E+04
RPD		8.53%	0.88%	4.77%	0.72%	0.24%	2.60%
	14:36:51	1.03E+01	6.58E+00	2.61E+00	1.18E+01	2.64E+01	1.17E+04
	14:39:24	8.73E+00	6.35E+00	2.69E+00	1.23E+01	2.75E+01	1.17E+04
RPD		16.50%	3.56%	3.02%	4.15%	4.08%	0.00%
	10:47:43	1.54E+01	4.33E+00	1.39E+00	1.15E+01	3.68E+01	1.30E+04
	10:49:58	1.16E+01	2.70E+00	1.08E+00	7.54E+00	1.70E+01	1.26E+04
RPD		28.15%	46.37%	25.10%	41.60%	73.61%	3.13%
	10:50:20	1.82E+00	1.67E+00	4.89E-01	1.18E+00	4.48E+00	8.05E+03
	10:53:05	1.14E+00	7.38E-01	2.67E-01	5.29E-01	1.97E+00	8.36E+03
RPD		45.95%	77.41%	58.73%	76.18%	77.83%	3.78%
	10:59:48	1.25E+00	5.25E-01	3.26E-01	2.46E-01	2.41E-01	8.07E+03
	11:02:23	1.25E+00	4.29E-01	1.10E-01	3.31E-02	6.32E-02	8.04E+03
RPD		0.00%	20.13%	99.08%	152.56%	116.90%	0.37%
	9:29:15	3.35E+00	1.15E+00	5.37E-01	6.98E-01	1.16E+00	8.14E+03
	9:31:54	6.52E-01	6.29E-01	3.28E-01	2.32E-01	5.05E-01	7.89E+03
RPD		134.83%	58.57%	48.32%	100.22%	78.68%	3.12%
	10:06:51	7.12E+00	5.12E+00	1.89E+00	8.30E+00	2.08E+01	8.14E+03
	10:09:03	7.44E+00	5.71E+00	2.25E+00	1.01E+01	2.46E+01	8.16E+03
RPD		4.40%	10.90%	17.39%	19.57%	16.74%	0.25%
	10:57:24	1.04E+01	2.64E+00	5.66E-01	7.01E+00	1.86E+01	8.02E+03
	10:59:35	1.07E+01	2.73E+00	5.69E-01	7.26E+00	1.87E+01	8.00E+03
RPD		2.84%	3.35%	0.53%	3.50%	0.54%	0.25%

Table A-2. (continued).

Sample Duplicates		$CHCl_3$	TCA	PCE	TCE	CCl_4	H_2O
	11:17:53	5.50E-01	1.54E-01	1.52E-01	9.34E-01	3.84E-01	7.96E+03
	11:20:02	2.05E+00	8.38E-01	3.32E-01	1.82E+00	4.23E+00	7.98E+03
RPD		115.38%	137.90%	74.38%	64.34%	166.71%	0.25%
	14:33:55	4.23E+00	2.91E+00	5.50E+00	5.00E+00	1.15E+01	1.32E+04
	14:36:15	1.76E+00	1.14E+00	6.69E-01	7.11E-01	2.29E+00	1.21E+04
RPD		82.47%	87.41%	156.62%	150.20%	133.58%	8.70%
	15:20:44	9.87E-01	3.07E-01	2.23E-01	8.63E-02	1.18E-01	1.06E+04
	15:22:59	1.05E+00	3.32E-01	1.84E-01	9.10E-02	5.82E-02	1.02E+04
RPD		6.19%	7.82%	19.16%	5.30%	67.88%	3.85%
	15:36:24	1.92E+00	9.72E-01	2.32E-01	4.90E-01	2.26E-01	9.06E+03
	15:39:07	1.94E+00	1.12E+00	1.73E-01	4.15E-01	2.40E-01	8.87E+03
RPD		1.04%	14.15%	29.14%	16.57%	6.01%	2.12%
	9:57:48	1.95E+00	1.02E+00	8.41E-01	3.08E+00	7.21E+00	5.51E+03
	10:00:32	2.00E+00	6.83E-01	6.63E-01	1.46E+00	2.95E+00	5.59E+03
RPD		2.53%	39.58%	23.67%	71.37%	83.86%	1.44%
	10:47:30	4.13E+00	1.83E+00	7.10E-01	2.74E+00	6.20E+00	6.36E+03
	10:50:16	5.02E+00	3.28E+00	1.51E+00	6.58E+00	1.37E+01	5.79E+03
RPD		19.45%	56.75%	72.07%	82.40%	75.38%	9.38%
	11:08:46	5.45E+00	3.21E+00	6.71E+00	9.02E-01	1.40E+00	6.17E+03
	11:11:10	5.83E+00	3.39E+00	6.80E+00	8.85E-01	1.38E+00	6.08E+03
RPD		6.74%	5.45%	1.33%	1.90%	1.44%	1.47%
	11:49:14	9.66E+01	2.92E+01	2.98E+00	1.00E+02	3.92E+02	6.47E+03
	11:52:07	1.02E+02	2.90E+01	2.91E+00	1.05E+02	3.88E+02	6.39E+03
RPD		5.44%	0.69%	2.38%	4.88%	1.03%	1.24%
	14:46:03	2.40E+01	6.18E+00	1.24E+00	2.08E+01	4.44E+01	9.83E+03
	14:48:18	2.27E+01	6.39E+00	1.01E+00	1.73E+01	4.02E+01	9.87E+03
RPD		5.57%	3.34%	20.44%	18.37%	9.93%	0.41%
	8:52:36	8.66E+00	6.68E+00	2.67E+00	1.10E+01	2.40E+01	6.86E+03
	8:55:11	8.70E+00	6.64E+00	2.64E+00	1.09E+01	2.36E+01	6.87E+03
RPD		0.46%	0.60%	1.13%	0.91%	1.68%	0.15%
	9:27:56	4.15E+00	5.28E+00	1.05E+00	4.30E+00	7.04E+00	6.87E+03
	9:30:08	4.63E+00	4.76E+00	1.06E+00	4.37E+00	7.83E+00	7.10E+03
RPD		10.93%	10.36%	0.95%	1.61%	10.63%	3.29%
	10:41:17	2.12E+00	2.89E+00	2.28E-01	5.84E-01	1.21E+00	7.10E+03
	10:43:27	2.28E+00	1.32E+00	1.75E-01	4.01E-01	1.07E+00	7.41E+03

Table A-2. (continued).

Sample Duplicates	Time	$CHCl_3$ (ppmv)	TCA (ppmv)	PCE (ppmv)	TCE (ppmv)	CCl_4 (ppmv)	H_2O (ppmv)
RPD		7.27%	74.58%	26.30%	37.16%	12.28%	4.27%
	11:07:27	4.97E+00	5.94E+00	5.01E-01	3.18E+00	7.17E+00	7.53E+03
	11:10:20	5.31E+00	8.71E+00	6.00E-01	3.49E+00	7.45E+00	7.80E+03
RPD		6.61%	37.82%	17.98%	9.30%	3.83%	3.52%
	11:24:17	3.44E+00	5.03E+00	4.61E-01	1.39E+00	4.10E+00	7.67E+03
	11:26:27	3.81E+00	8.04E+00	4.93E-01	1.83E+00	4.85E+00	7.79E+03
RPD		10.21%	46.06%	6.71%	27.33%	16.76%	1.55%
	12:32:42	2.57E+00	6.68E+00	1.13E-01	7.65E-01	3.51E-01	8.46E+03
	12:35:04	2.65E+00	6.56E+00	1.17E-01	6.71E-01	3.59E-01	8.62E+03
RPD		3.07%	1.81%	3.48%	13.09%	2.25%	1.87%
	13:22:21	2.71E+00	3.24E+00	1.46E-01	3.04E-01	4.54E-01	9.53E+03
	13:24:53	2.77E+00	1.47E+00	1.32E-01	1.62E-01	3.02E-01	9.43E+03
RPD		2.19%	75.16%	10.07%	60.94%	40.21%	1.05%

$CHCI_3$ = chloroform
CCI_4 = carbon tetrachloride
H_2O = water
PCE = tetrachlorethylene
RPD = relative percent difference
TCA = trichloroethane
TCE = trichoroethylene